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(54) **METHOD, DEVICE AND COMPUTER PROGRAM FOR DETERMINING STRETCH VALUES**

VERFAHREN, VORRICHTUNG UND COMPUTERPROGRAMMPRODUKT ZUR DEHNUNGSBERECHNUNG

PROCÉDÉ, DISPOSITIF ET PRODUIT PROGRAMME INFORMATIQUE POUR MESURE D'ÉTIREMENT

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Description

FIELD OF THE INVENTION

[0001] The invention relates to a method for determining movement of a human or animal body part on basis of measured stretch data.

BACKGROUND OF THE INVENTION

[0002] A non-optimal movement pattern of the body or parts of the body is a major cause of pain and lesions or injuries in the locomotion system. Movement analysis is crucial for prophylaxis, diagnosing and treatment of such lesions, and in sports an optimal movement pattern is essential for optimal and injury free performance.

[0003] Until now movement analysis has primarily been performed by monitoring movement of points on the body during motion, e.g. by use of advanced video technology where retro reflective optical markers on the body are tracked during motion with one or multiple video cameras. However, such video-based methods for analysing body motion and body loads are impractical since they normally require use of a treadmill and large dedicated rooms.

[0004] Accordingly, there is a need to enable monitoring of body motion without restricting the motion to be carried out in a particular environment, room or with use of a treadmill.

[0005] US 2010324457 discloses a system that records position data for portions of a body as a function of time. The position data can be collected from one or more sensors secured to the body either individually or using a patch. The sensors, in some embodiments, can include stretch sensors that produce a change in electrical resistance as the stretch sensors are stretched as a result of body movement. A data logger can be used to record the data. Various other elements such as a feedback mechanism or a manual pain indicator can also be included.

[0006] US 2009/0165190 A1 describes a compression sock to provide compression to various areas of the foot of a user. A test is describes involving a stretch sensor with a conductive substance changing resistance as the sensor changes shape. The stretch sensor is attached to the foot to measure changes in arch circumference during walk, hereby determine to what extent the sock maintains the shape of the arch of the bottom of the foot formed from the longitudinal plantar arch and the transverse plantar arch.

[0007] The inventor of the present invention has appreciated that improved methods analysing body motion for determining body load is of benefit, and has in consequence devised the present invention.

SUMMARY OF THE INVENTION

[0008] It would be advantageous to achieve improved method for determining body loads during motion. It would also be desirable to enable determination of body loads without restricting the motion to be performed in a particular environment. In general, the invention preferably seeks to mitigate, alleviate or eliminate one or more of the above mentioned disadvantages singly or in any combination. In particular, it may be seen as an object of the present invention to provide a method that solves the above mentioned problems, or other problems, of the prior art.

[0009] To better address one or more of these concerns, in a first aspect of the invention a sensor device is presented that is configured to process stretch data from a stretch sensor for determining a stretch value of a body part, where the sensor device comprises a processor,
where the stretch sensor and the sensor device are configured to carry out the steps of claim 1.

[0010] It is understood that the first and second stretch data points are separated in time and located within a cyclic period of the stretch data.

[0011] Since the sensor device is configured to determine a stretch value from specific stretch data samples of the measured stretch data - where the specific stretch data samples are associated with specific motion phases - it is ascertained that the stretch value is indicative of a particular stretch directly related, e.g. to the navicular drop. The motion phases may be predefined phases such as particular motion phases of a foot.

[0012] The determination of stretch values may be used for determining movement of the body part, i.e. high stretch values which may indicate a high harmful overload. The sensor device may be used by professionals for determining load values of patients or the sensor device may be used by non-professionals e.g. by athletes for determining the load of a body part during training. For example, the sensor device may be used by runners for avoiding overloading of the foot by determining when the stretch values of the foot are becoming too high. Thereby, the athlete is able to maximize training efforts without the risk of overload injuries.

[0013] Herein the word movement is used to define the stretch or movement of a body part, i.e. a stretch or movement between two points on a body part, such as between the tuberosity of the navicular bone and the center of the medial malleolus. The movement may be used for assessing the load of the particular body part. The word motion is used to define e.g. walking, running or other motions of a body part.

[0014] The sensor device is particularly advantageous since it enables determination of stretch values by use of a single sensor. That is, no other sensors than a stretch sensor is required since the sensor device enables determination of stretch values in a way so that the stretch values are synchronized with the body motion.

[0015] In an embodiment of the invention the body part is a foot, where the portion of the stretch data corresponds to a walking or running motion, where the first motion-phase of the foot is the heel strike, and where the second motion-phase of the foot is the mid stance, i.e. the phase where both the toe and the heel are in contact with the ground.

[0016] In an embodiment the first data point is determined by determining a minimum value within at least a fraction of the identified portion of the stretch data and the second data point is determined by determining a maximum value within at least a fraction of the determined portion of the stretch data.

[0017] In an embodiment the second data point is determined by determining a maximum value within at least a fraction of the portion of the stretch data and the first data point is determined by determining a minimum value located in time before the second data point.

[0018] The stretch data may have a profile so that the maximum value always corresponds to a specific motion phase (e.g. both heel and toes are in contact with ground) and so that the minimum value located in the determined portion of the stretch data and before the maximum value always corresponds to another specific motions phase (heel impact).

[0019] In an embodiment of the processor comprised by the sensor device is further configured for determination of a period of time between the first and second stretch data points. This period may advantageously be used as a second measure (in addition to the first measure of stretch data) for determining the movement of the body part. E.g. a period of time between the first and second stretch data points which increases may indicate a decreased stability (corresponds to a softness) of the body part and, thereby, an increased risk of an overload injury.

[0020] In an embodiment the period of time between the first and second stretch data points is compared with a period of time of the cyclic walking motion for determination of the stability of the body part.

[0021] In an embodiment the sensor device further comprises a processor or filtering electronics for low pass filtering the stretch data.

[0022] A second aspect of the invention relates to a sensor system according to claim 8.

[0023] The stretch sensor may be a capacitive or resistive sensor which changes its capacitance or resistance as a function of elongation. Accordingly, stretch data can be determined from the stretch sensor by monitoring changes in the sensor's electrical characteristics.

[0024] A third aspect of the invention relates to a computer program according to claim 9.

[0025] In summary the invention relates to a method for determining stretch values and loading of body parts, e.g. a foot, by analysing stretch data from a stretch sensor. By analysing the stretch sensor it is possible to determine stretch samples which are associated with particular motion phases. Thereby the stretch values determined from the stretch samples have a particular physical meaning since they are associated with particular motion phases.

[0026] In general the various aspects of the invention may be combined and coupled in any way possible within the scope of the invention as defined by the appended claims. These and other aspects, features and/or advantages of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] Embodiments of the invention will be described, by way of example only, with reference to the drawings, in which

Fig. 1 shows a curve 100 of measured stretch data,
Fig. 2 shows a stretch sensor 201 attached to a foot for determining a stretch of the foot such as navicular drop,
Fig. 3 shows sensor device 301 configured to process stretch data from a stretch sensor 302, and
Fig. 4 shows a second example of a curve 400 of measured stretch data.

DETAILED DESCRIPTION OF EMBODIMENTS

[0028] Fig. 1 shows a stretch data curve 100 of measured stretch data from a stretch sensor. The stretch data curve 100 is analyzed by a sensor device for determining a stretch value 103 of e.g. a foot.

[0029] Fig. 2 shows a stretch sensor 201 attached to a foot for measuring a stretch of the foot. In Fig. 2 the sensor is located close to the points 202 (the tuberosity of the navicular bone), and 203 (the center of the medial malleolus) for measuring the navicular drop 210 of the point 202. The heel part 205 and the toe part 204 of the foot are also indicated. A stretch of the foot such as the navicular drop 210 is indicative for the load of the foot.

[0030] From the stretch data curve 100 in Fig. 1 it is possible to determine stretch values of the foot. However, in order to relate the measured stretch to e.g. load of the foot the measured stretch has to be associated with a particular motion of the foot. By identifying particular motion phases of the foot the stretch values measured when the foot is in these phases can be used to quantify the load of the foot. An example of determining a stretch for a particular motion of the foot is given below.

[0031] The motion of the foot is shown in Fig. 1 with three motion phases 111-113. The first motion phase 111 is the heel strike where the heel 205 contacts the ground, the second motion phase 112 is the mid stance, i.e. the phase where both the toe 204 and the heel 205 contacts the ground and the third phase 113 is the toe-off, i.e. the phase where only the toe 204 contacts the ground before set-off.

[0032] In the second phase 112 the stretch between the first and second points 202,203 are maximal, and in the first phase 111 the stretch between the first and second points 202,203 are minimal. Accordingly, the difference between the stretch values in the first and second phases 111, 112 gives a measure of the loading of the foot during walking or running.

[0033] In Fig. 1 the measured stretch value or sensor value 121 at the first stretch data point 101 corresponding to the first motion phase 111, is a global minimal value during the entire data curve 100 or at least during a motion period 106. Similarly, the sensor value 122 at the second stretch data point 102 corresponding to the second motion phase 112, is a global maximal value during the entire data curve 100 or at least during a motion period 106. Accordingly, in an embodiment the first and second stretch data points 101, 102 could simply be determined by determining the minimal and maximal sensor values 121,122 in a given time interval of the data curve 100. However, since it may be important that the determined stretch data points are associated with particular predetermined motion phases, this simple approach could lead to an incorrect stretch value 103 if e.g. the minimum value of some reason is not located at the first motion phase 111, but at some other motion phase 143.

[0034] As an example, Fig. 4 shows a stretch data curve 400 of measured stretch data from a stretch sensor. In Fig. 4 the sensor value of the first stretch data point 401 corresponding to the first motion phase 111, is not a minimal value within a motion period 406. Only the sensor value at the second stretch data point 402 corresponding to the second motion phase 112 is a maximal value during a motion period. The minimum value is located at some other motion phase 443. Accordingly, Fig. 4 shows an example where the first stretch point 401 cannot be determined by the simple approach where the first stretch point 401 is assumed to be a minimum value during a motion period.

[0035] To avoid incorrectly determined stretch values, the stretch data 100 is advantageously analyzed to identify a portion 104 of the stretch data which corresponds to some motion cycle (e.g. the cycle comprising motion phases 111-113) of e.g. the foot, where data is analyzed in a way so that this portion 104 contains the first and second stretch data points 101,102 associated with the respective first and second motion-phases 111,112 of the foot.

[0036] The portion 104 may be identical to an entire period 106 or the portion may be a fraction of a complete period 106. Here a period is understood as a period of a harmonic signal, for example the cyclic data curve 100.

[0037] The portion 104 of the stretch data containing the first and second data points 101,102 may be identified from a correlation analysis of the stretch data to identify e.g. the high frequency dip of the curve 100 near the start point 141 of a period and the low frequency dip near the end point 142 so as to identify the illustrated fraction 104 of an entire period 106 of the cyclic motion pattern. Accordingly, the portion 104 of the stretch data 100 may be determined by determining a start point 141 and an end point 142 so that the stretch data contained between the start point 141 and the end point 142 corresponds to at least a fraction of one period 106 of a period of the motion.

[0038] Having identified the portion 104 of stretch data 100 the first and second sensor values 121, 122 of the respective first and second stretch data points 101,102 can be determined, and from the sensor values 121, 122 a resulting stretch value 103 can be determined, e.g. by determining the difference between the first and second sensor values 121, 122.

[0039] Having identified the portion 104 of the stretch data, the first data point 101 may be determined by determining a minimum value within at least a fraction of the identified portion, e.g. a first fraction including the start point of the portion 104 and having a given duration equal to a fraction of the duration of the entire portion 104. Similarly, the second data point 102 may be determined by determining a maximum value within at least a fraction of the determined portion 104 of the stretch data, e.g. a second fraction starting where first fraction ends and ending at the end point of the portion 104.

[0040] Assuming that the second data point 102 can be uniquely identified from the maximum value of the stretch data, then according to an embodiment the second data point 102 can be determined by determining a maximum value within at least a fraction of the portion 104 of the stretch data 100. Having initially identified the second data point, the first data point 101 can be determined by determining a minimum value located in time before the second data point 102 and within the portion 104.

[0041] From the above discussion it is clear that a period 106 or a fraction thereof, i.e. a portion 104, can be identified by analysing the stretch data signal e.g. by frequency analysis. It is also clear that the first and second data points 101, 102 corresponding to first and second motion phases 111, 112 can be identified by analysing the data within the identified period 106 or portion 104 thereof, e.g. by searching for minimal and maximal values, e.g. by use of a peak detector.

[0042] In an aspect of the invention a period of time 105 between the first and second stretch data points 101, 102 is determined e.g. by calculating the difference of the time stamps of the first and second stretch data points. The period of time 105 gives an indication of the softness of the foot or other body part and, thereby, an indication of the loading of the foot since the softness tends to increase with increased loading of the foot. Accordingly, the change of the period of time 105 during monitoring of stretch data 100 may be used for assessing the softness of the foot. A decrease in the time period corresponds to an increase in softness. The period of time 105 may be compared with the period of time 106 of the cyclic motion, or a fraction 104 thereof, to get an absolute measure of the softness of the body part such as the foot.

[0043] The sensor values from the stretch sensor may be noisy and, therefore, a processor or filtering electronics for low pass filtering the stretch data may be used.

[0044] Fig. 3 shows a sensor system 300 which comprises the sensor device 301 for analysing stretch data and a stretch sensor 302. The sensor device 301 may include a processor 303 configured for analysing the stretch data and determining stretch values 103. The processor need not be part of the sensor device 301.

[0045] The sensor system 300 may be configured in various ways. The sensor device 301 may be an electronic device configured to be carried by the user, e.g. on a wrist.

[0046] Such a sensor device may receive stretch data wirelessly from the stretch sensor which may include a transmitter for transmitting data to a receiver of the sensor device 301. The sensor device 301 may include a display for displaying results of determined stretch values. The sensor device may be configured so that only part of the processing of stretch data 100 is carried out by the sensor device 301 whereas other parts of the processing of stretch data may be carried out by other processing devices, e.g. a computer which is connectable to the sensor device 301. Accordingly, the sensor device 301 may contain a storage for storage of stretch data or processed stretch data, so that another processor unit may be connected (wirelessly or wired) to the sensor device. The stretch sensor 302 may also contain a processor and or a storage for storing measured stretch data 100 so that the sensor device 301 or some other processor may be connected to the stretch sensor 302 via a transmitter-receiver pair for further processing of the stored stretch data.

[0047] Whereas the determination of stretch values and analysis of stretch values has been described on basis of a foot and foot motion, the invention is equally applicable to other body parts and their motion phases. For example, the stretch sensor may be attached to the shoulder of a person in order to determine stretch values of shoulder by identifying a portion 104 of the stretch data which corresponds to at least a fraction of a complete period of cyclic motion of the shoulder, where the portion of the stretch data is identified so that the portion contains first and second stretch data points 101, 102 associated with respective first and second motion-phases of the shoulder, and by analysing the identified portion of stretch data to determine first and second sensor values 121, 122 so that a stretch value 103 can be determined. The invention described herein may be applicable to determining stretch values of body parts where a cyclic motion of the body part can be identified.

[0048] The stretch sensor 302 may be connected to a body part by connecting the sensor directly to the skin (e.g. by use of some adhesive material), or the sensor may be indirectly attached, e.g. by integrating the sensor with a sock or a shoe.

[0049] An implementation example may include socks, shoes or bandages wherein the sensor system or the stretch sensor is integrated for enabling indirect attachment of the sensor.

[0050] Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. A single processor or other unit may fulfill the functions of several items recited in the claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage. A computer program may be stored/distributed on a suitable medium, such as an optical storage medium or a solid-state medium supplied together with or as part of other hardware, but may also be distributed in other forms, such as via the Internet or other wired or wireless telecommunication systems. Any reference signs in the claims should not be construed as limiting the scope.

Claims

1. A method for determining stretch values of a body part, wherein the body part includes first and second points that move relative to each other when the body part moves, the method comprises,

- connecting a stretch sensor to the body near both the first and second points such that movement of the first point relative to the second point changes elongation of the stretch sensor,where the stretch sensor is a capacitive or resistive sensor, which changes its capacitance or resistance as a function of elongation,
- while moving the body part, while moving the body part, obtaining stretch data from the stretch sensor by a processor associated with the stretch sensor,
- processing, by the processor, the stretch data obtained from the stretch sensor with a sensor device to determine a stretch value of the body part, wherein the processor is configured to perform the method by:

  - analysing the stretch data as cyclic stretch data,
  - analysing the stretch data to identify portions (104) of the cyclic stretch data (100) which correspond to motions of the body part, where the portions of the stretch data are identified so that the portions contain first and second stretch data points (101, 102) associated with respective first and second motion-phases of the body part,
  - analysing the cyclic stretch data (100) to identify first and second stretch values (101, 102) by determining minimum and maximum sensor values (121,122),
  - further analysing the cyclic stretch data

(100) to identify the portions (104) ensuring that the portions (104) contain an entire period (106) of a cyclic harmonic signal containing first and second stretch data points (101, 102) associated with respective first and second motion-phases of the body part and to identify values related to other motion phases (143, 443),
- analysing the identified portions (104) of cyclic stretch data (100) to determine first and second sensor values (121, 122) of the respective first and second stretch data points (101,102),
- determining stretch values (103) by determining the differences between the first and second sensor values (121, 122) associated respectively with the first and second motion-phases, and
- transmitting the determined stretch values (103) to a receiver associated with the processor.

2. A method according to claim 1, where the body part is a foot, where the portion (104) of the stretch data corresponds to a walking or running motion, where the first motion-phase of the foot is a heel strike (111), and where the second motion-phase of the foot is the phase where both the toe (204) and the heel (205) contacts the ground (112).

3. A method according to any of the preceding claims, where a first data point (101) is determined by determining a minimum value within at least a fraction of an identified portion (104) of the stretch data and a second data point (102) is determined by determining a maximum value within at least a fraction of said determined portion (104) of the stretch data.

4. A method according to any of the preceding claims, where a second data point (102) is determined by determining a maximum value within at least a fraction of a portion (104) of the stretch data and where a first data point (101) is determined by determining a minimum value located in time before the second data point (102).

5. A method according to any of the preceding claims, comprising determination of a period of time (105) between the first and second stretch data points within a portion (104) of the stretch data.

6. A method according to claim 5, where the period of time (105) between the first and second stretch data points is compared with a period of time (104) of a cyclic walking motion for determination of a softness of the body organ.

7. A method according to any of the preceding claims, where a processor or filtering electronics is used for low pass filtering the stretch data.

8. A sensor system comprising

- a stretch sensor (201, 302) configured to be directly connected to a body part for determining stretch or movement values of a body part,
- a sensor device comprising a processor and in communication with the stretch sensor,

wherein the sensor device and the stretch sensor are configured to perform the method according to any of claims 1-7.

9. A computer program containing computer program instructions for enabling the processor in the sensor system of claim 8 to carry out the method according to any of claims 1 - 7.

Patentansprüche

1. Verfahren zur Bestimmung von Dehnungswerten eines Körperteils, wobei der Körperteil erste und zweite Punkte beinhaltet, die sich relativ zueinander bewegen, wenn sich der Körperteil bewegt, wobei das Verfahren umfasst,

- Verbinden eines Dehnungssensors mit dem Körper in der Nähe sowohl des ersten als auch des zweiten Punktes, so dass die Bewegung des ersten Punktes relativ zu dem zweiten Punkt die Ausdehnung des Dehnungssensors ändert, wobei der Dehnungssensor ein kapazitiver oder resistiver Sensor ist, der seine Kapazität oder seinen Widerstand als Funktion der Ausdehnung ändert,
- während der Bewegung des Körperteils, während der Bewegung des Körperteils, Erhalten von Dehnungsdaten von dem Dehnungssensor durch einen dem Dehnungssensor zugeordneten Prozessor,
- Verarbeiten der von dem Dehnungssensor erhaltenen Dehnungsdaten durch den Prozessor mit einer Sensorvorrichtung zum Bestimmen eines Dehnungswertes des Körperteils, wobei der Prozessor konfiguriert ist, um das Verfahren durchzuführen durch:

- Analysieren der Dehnungsdaten als zyklische Dehnungsdaten,
- Analysieren der Dehnungsdaten, um Abschnitte (104) der zyklischen Dehnungsdaten (100) zu identifizieren, die Bewegungen des Körperteils entsprechen, wobei die Abschnitte der Dehnungsdaten so identifiziert werden, dass die Abschnitte erste und zwei-

te Dehnungsdatenpunkte (101, 102) enthalten, die entsprechenden ersten und zweiten Bewegungsphasen des Körperteils zugeordnet sind,
- Analysieren der zyklischen Dehnungsdaten (100), um erste und zweite Dehnungswerte (101, 102) durch Bestimmen minimaler und maximaler Sensorwerte (121, 122) zu identifizieren,
- weiter Analysieren der zyklischen Dehnungsdaten (100), um die Abschnitte (104) zu identifizieren, sicherstellend, dass die Abschnitte (104) eine gesamte Periode (106) eines zyklischen, harmonischen Signals enthalten, das erste und zweite Dehnungsdatenpunkte (101, 102) enthält, die entsprechenden ersten und zweiten Bewegungsphasen des Körperteils zugeordnet sind, und um Werte zu identifizieren, die sich auf andere Bewegungsphasen (143, 443) beziehen,
- Analysieren der identifizierten Abschnitte (104) der zyklischen Dehnungsdaten (100), um erste und zweite Sensorwerte (121, 122) der entsprechenden ersten und zweiten Dehnungsdatenpunkte (101, 102) zu bestimmen,
- Bestimmen von Dehnungswerten (103) durch Bestimmen der Differenzen zwischen den ersten und zweiten Sensorwerten (121, 122), die entsprechend den ersten und zweiten Bewegungsphasen zugeordnet sind, und
- Senden der bestimmten Dehnungswerte (103) an einen Empfänger, der dem Prozessor zugeordnet ist.

2. Verfahren nach Anspruch 1, wobei der Körperteil ein Fuß ist, wobei der Abschnitt (104) der Dehnungsdaten einer Geh- oder Laufbewegung entspricht, wobei die erste Bewegungsphase des Fußes ein Fersenauftritt (111) ist und wobei die zweite Bewegungsphase des Fußes die Phase ist, in der sowohl die Zehen (204) als auch die Ferse (205) den Boden (112) berühren.

3. Verfahren nach einem der vorstehenden Ansprüche, wobei ein erster Datenpunkt (101) durch Bestimmen eines minimalen Wertes innerhalb zumindest eines Bruchteils eines identifizierten Abschnitts (104) der Dehnungsdaten bestimmt wird und ein zweiter Datenpunkt (102) durch Bestimmen eines maximalen Wertes innerhalb zumindest eines Bruchteils des bestimmten Abschnitts (104) der Dehnungsdaten bestimmt wird.

4. Verfahren nach einem der vorstehenden Ansprüche, wobei ein zweiter Datenpunkt (102) durch Bestimmen eines maximalen Wertes innerhalb zumindest eines Bruchteils eines Abschnitts (104) der Dehnungsdaten bestimmt wird und wobei ein erster Datenpunkt (101) durch Bestimmen eines minimalen Wertes bestimmt wird, der sich in der Zeit vor dem zweiten Datenpunkt (102) befindet.

5. Verfahren nach einem der vorstehenden Ansprüche, umfassend die Bestimmung einer Zeitspanne (105) zwischen den ersten und zweiten Dehnungsdatenpunkten innerhalb eines Abschnitts (104) der Dehnungsdaten.

6. Verfahren nach Anspruch 5, wobei die Zeitspanne (105) zwischen den ersten und zweiten Dehnungsdatenpunkten mit einer Zeitspanne (104) einer zyklischen Gehbewegung zur Bestimmung einer Weichheit des Körperorgans verglichen wird.

7. Verfahren nach einem der vorstehenden Ansprüche, wobei ein Prozessor oder eine Filterelektronik zum Tiefpassfiltern der Dehnungsdaten verwendet wird.

8. Sensorsystem umfassend

- einen Dehnungssensor (201, 302), der konfiguriert ist, um direkt mit einem Körperteil verbunden zu sein, um Dehnungs- oder Bewegungswerte eines Körperteils zu bestimmen,
- eine Sensorvorrichtung, die einen Prozessor umfasst und mit dem Dehnungssensor in Verbindung steht, wobei die Sensorvorrichtung und der Dehnungssensor konfiguriert sind, um das Verfahren nach einem der Ansprüche 1-7 durchzuführen.

9. Computerprogramm, das Computerprogrammanweisungen enthält, um dem Prozessor in dem Sensorsystem nach Anspruch 8 zu ermöglichen, das Verfahren nach einem der Ansprüche 1-7 auszuführen.

Revendications

1. Procédé pour déterminer des valeurs d’étirement d’une partie corporelle, dans lequel la partie corporelle comprend des premier et second points qui se déplacent l’un par rapport à l’autre lorsque la partie corporelle se déplace, le procédé comprenant les étapes consistant à,

- connecter un capteur d’étirement au corps à proximité à la fois des premier et second points de telle sorte qu’un déplacement du premier point par rapport au second point change un allongement du capteur d’étirement, le capteur d’étirement étant un capteur capacitif ou résistif,

qui modifie sa capacité ou résistance en fonction de l'allongement,
- tout en déplaçant la partie corporelle, tout en déplaçant la partie corporelle, obtenir des données d'étirement auprès du capteur d'étirement par un processeur associé au capteur d'étirement,
- traiter, par le processeur, les données d'étirement obtenues auprès du capteur d'étirement à l'aide d'un dispositif capteur afin de déterminer une valeur d'étirement de la partie de corps, le processeur étant configuré pour mettre en œuvre le procédé consistant à :

  - analyser les données d'étirement en tant que données d'étirement cycliques,
  - analyser les données d'étirement pour identifier des parties (104) des données d'étirement cycliques (100) qui correspondent à des mouvements de la partie corporelle, les parties des données d'étirement étant identifiées de sorte que les parties contiennent des premier et second points de données d'étirement (101, 102) associés à des première et second phases de mouvement respectives de la partie corporelle,
  - analyser les données d'étirement cycliques (100) pour identifier des première et seconde valeurs d'étirement (101, 102) en déterminant des valeurs de capteur minimale et maximale (121, 122),
  - analyser en outre les données d'étirement cycliques (100) pour identifier les parties (104) en s'assurant que les parties (104) contiennent une période entière (106) d'un signal harmonique cyclique contenant des premier et second points de données d'étirement (101, 102) associés à des première et seconde phases de mouvement respectives de la partie corporelle et pour identifier des valeurs associées à d'autres phases de mouvement (143, 443),
  - analyser les parties identifiées (104) de données d'étirement cycliques (100) pour déterminer des première et seconde valeurs de capteur (121, 122) des premier et second points de données d'étirement respectifs (101, 102),
  - déterminer des valeurs d'étirement (103) en déterminant les différences entre les première et seconde valeurs de capteur (121, 122) associées respectivement aux première et seconde phases de mouvement, et
  - transmettre les valeurs d'étirement déterminées (103) à un récepteur associé au processeur.

2. Procédé selon la revendication 1, dans lequel la partie corporelle est un pied, la partie (104) des données d'étirement correspondant à un mouvement de marche ou de course, dans lequel la première phase de mouvement du pied est un impact de talon (111), et dans lequel la seconde phase de mouvement du pied est la phase où l'orteil (204) et le talon (205) entrent tous deux en contact avec le sol (112).

3. Procédé selon l'une quelconque des revendications précédentes, dans lequel un premier point de données (101) est déterminé en déterminant une valeur minimale dans au moins une fraction d'une partie identifiée (104) des données d'étirement et un second point de données (102) est déterminé en déterminant une valeur maximale dans au moins une fraction de ladite partie déterminée (104) des données d'étirement.

4. Procédé selon l'une quelconque des revendications précédentes, dans lequel un second point de données (102) est déterminé en déterminant une valeur maximale dans au moins une fraction d'une partie (104) des données d'étirement et dans lequel un premier point de données (101) est déterminé en déterminant une valeur minimale située dans le temps avant le second point de données (102).

5. Procédé selon l'une quelconque des revendications précédentes, comprenant la détermination d'une période de temps (105) entre les premier et second points de données d'étirement dans une partie (104) des données d'étirement.

6. Procédé selon la revendication 5, dans lequel la période de temps (105) entre les premier et second points de données d'étirement est comparée à une période de temps (104) d'un mouvement de marche cyclique pour déterminer une souplesse de l'organe corporel.

7. Procédé selon l'une quelconque des revendications précédentes, dans lequel un processeur ou un composant électronique de filtrage est utilisé pour filtrer passe-bas les données d'étirement.

8. Système capteur comprenant

  - un capteur d'étirement (201, 302) configuré pour être connecté directement à une partie corporelle pour déterminer des valeurs d'étirement ou de mouvement d'une partie corporelle,
  - un dispositif capteur comprenant un processeur et en communication avec le capteur d'étirement,

dans lequel le dispositif capteur et le capteur d'étirement sont configurés pour effectuer le procédé selon l'une quelconque des revendications 1 à 7.

9. Programme d'ordinateur contenant des instructions de programme d'ordinateur pour permettre au processeur dans le système capteur de la revendication 8 de mettre en œuvre le procédé selon l'une quelconque des revendications 1 à 7.

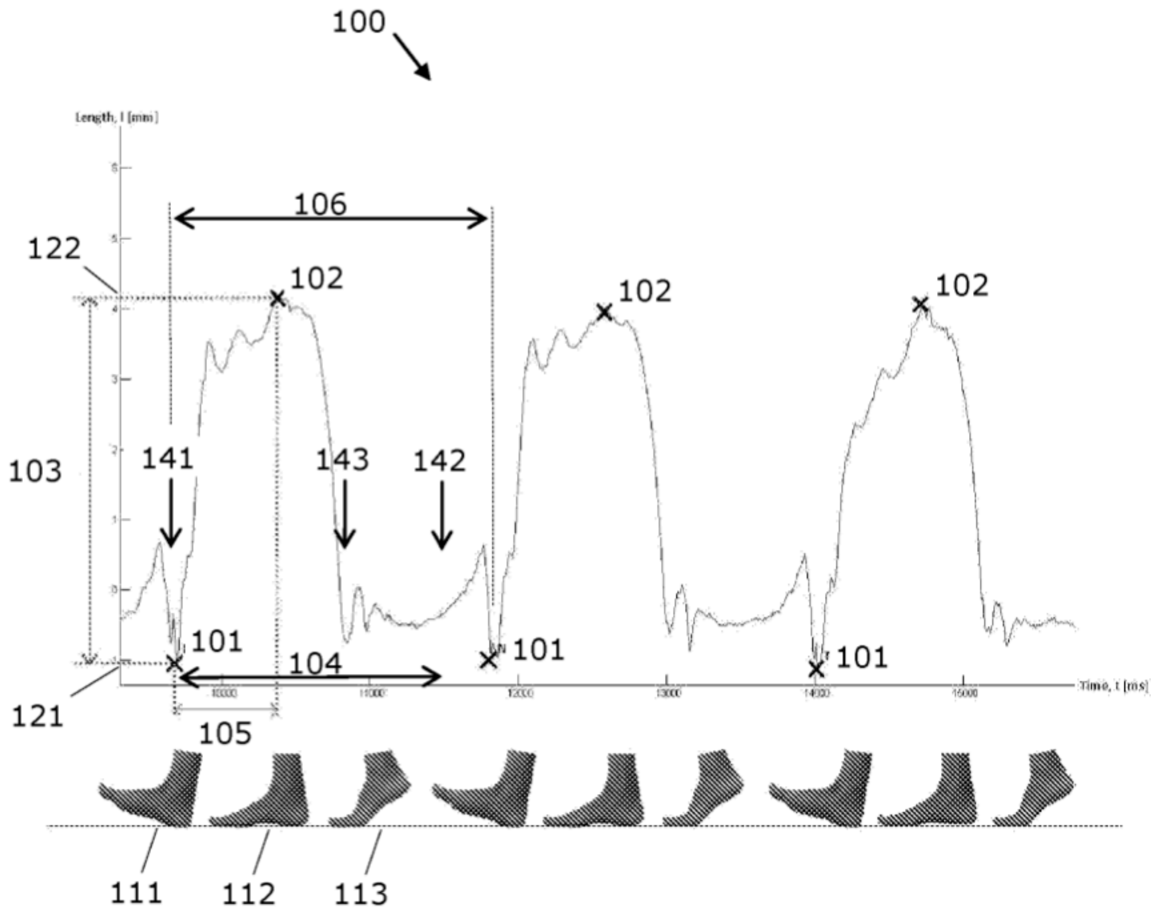
100
Length, l [mm]
106
122
102
102
102
103
141
143
142
101
101
101
104
121
105
Time, t [ms]
111
112
113

Fig. 1

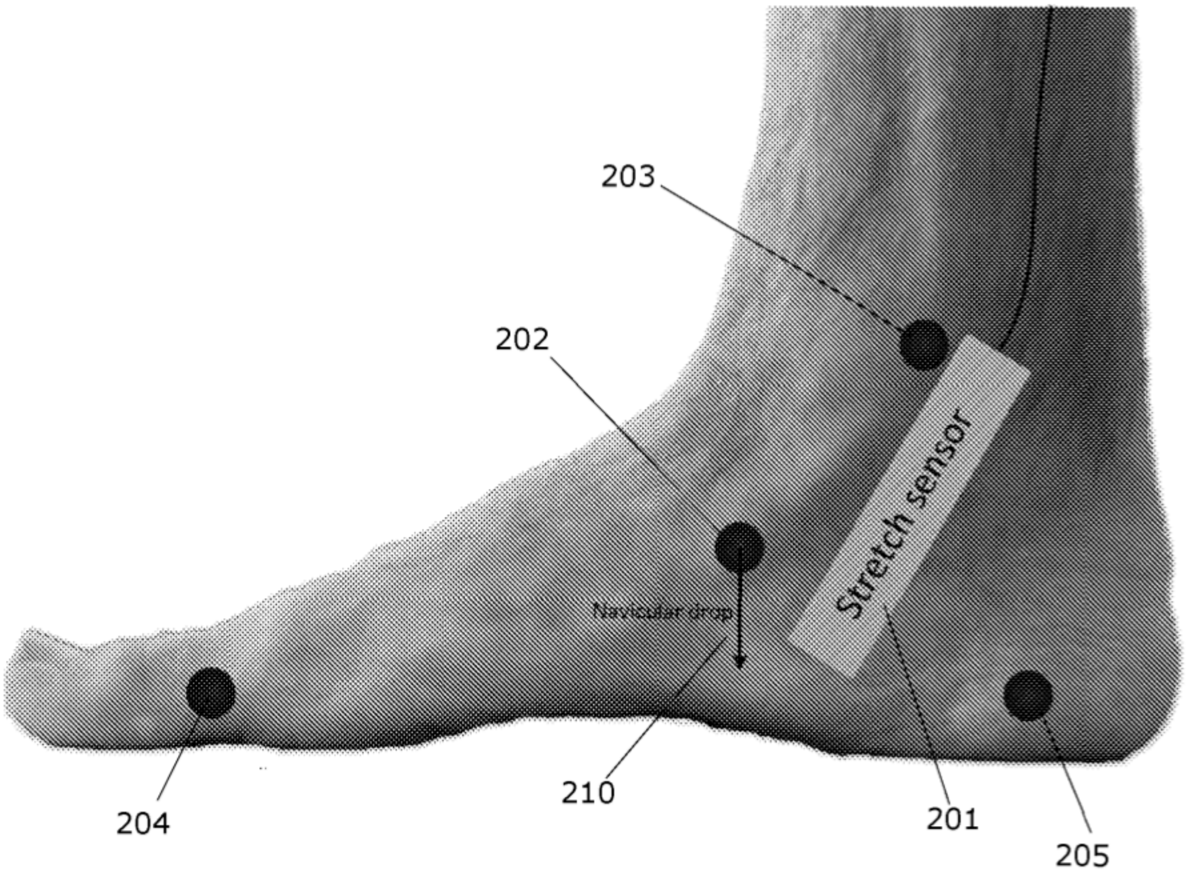

Fig. 2

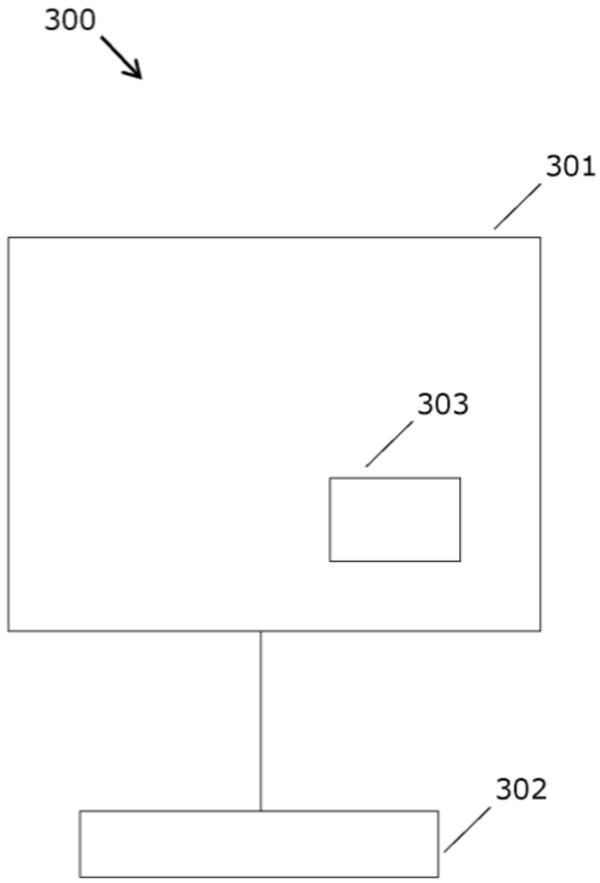

Fig. 3

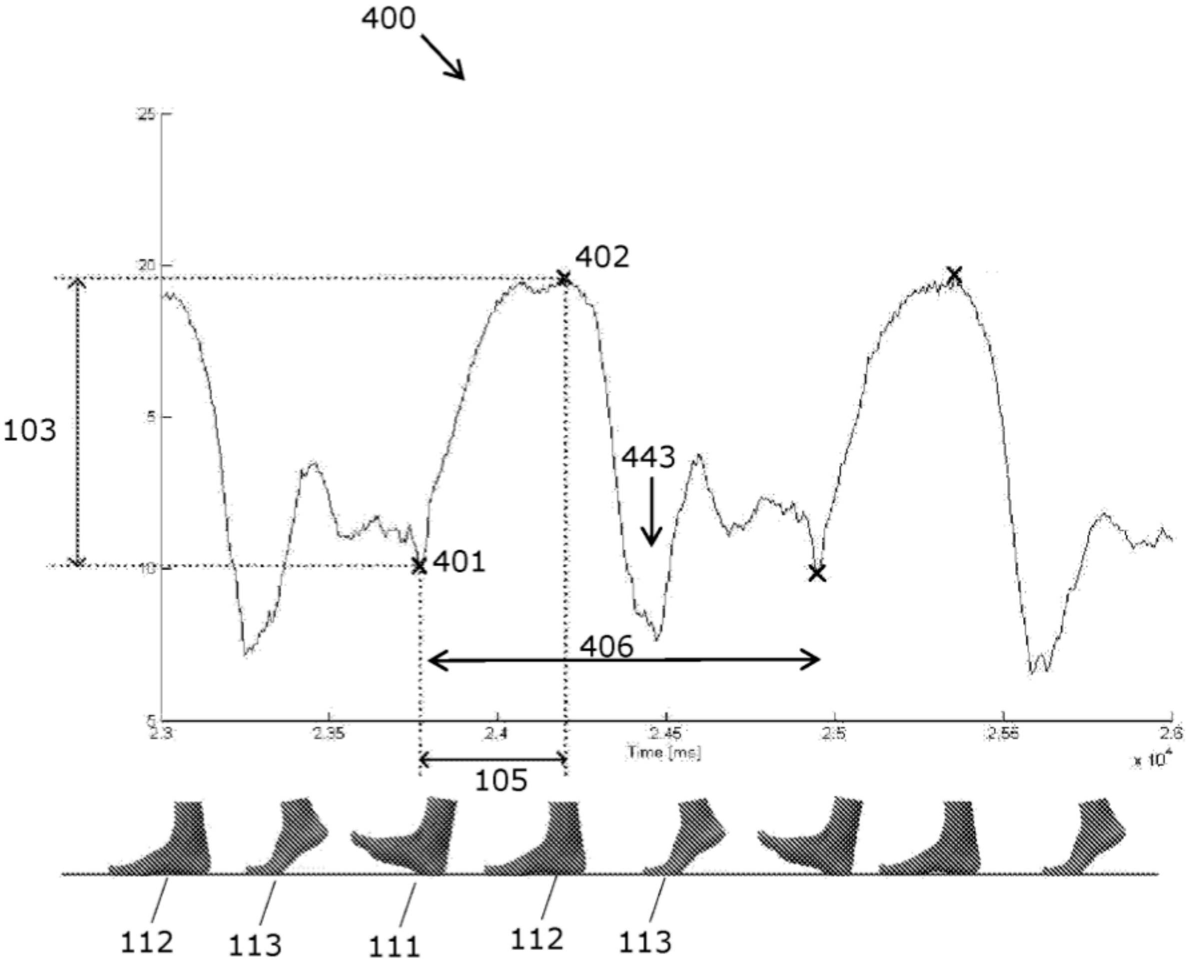

Fig. 4

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- US 20090165190 A1 **[0006]**